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It is widely recognized that physical environments directly affect human physiological and mental well-being. Noise, a recognized environmental stressor, contributes to poor patient satisfaction and is known to disrupt patient sleep. This study investigated the relationship of sources of noise to sleep disruption in three units of a large urban hospital. A volunteer sample of 61 discharged patients completed a survey asking about the sleep disruptive nature of 33 (25 noise related and 8 non-noise related) environmental factors. The results revealed that a total of 17 factors were found to be sleep-disruptive by at least one-third of the patients (11 noise-related and 6 not associated with noise). Beeping of the IV pump, intercom paging within the room and activities associated with a nurse entering the room were ranked the highest among noise-related factors. Comfort of the bed and nursing/medical interventions were the two factors with most responses in the non-noise category.

Based on these findings a set of design recommendations was developed that hospitals might adopt to eliminate the source of a noise, reduce its occurrence, or lessen its volume. Two key design recommendations consist of incorporating all private patient rooms and decentralizing nurses' stations. These conditions hold the potential for reducing the noise generated by staff conversations and excessive traffic by providing all essential elements of care within near proximity of the patient room and eliminating noise generated within the room by the presence and care associated with another patient. Additional recommendations include relatively specific design changes such as replacing

sound indicators with light-indicators on medical equipment, reducing staff bedside checks by providing visual access into patient's room from the corridor and using floor finishes with sound absorbing qualities and walls with sound attenuation materials. Design recommendations were developed for each harmful stressor identified by at least one-third of the respondents and were organized by the location of the source (bedside, room, and corridor). Recommendations include a list of possible solutions to prevent or reduce the noise at its source, and also to provide a space capable of preventing the transmission of sound once it is generated. Additional recommendations were made as related to the behavioral/operational factors and non-noise factors such as the patient bed, pillows, temperature and lighting. Overall the study found that noise is a factor which negatively affects patient sleep. The presence of noise can be reduced with a well-informed design approach.

IDENTIFYING SLEEP-DISRUPTIVE NOISE FACTORS IN HEALTHCARE ENVIRONMENTS

by

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CHAPTER I

INTRODUCTION

While all functions of sleep are not clearly understood, it is generally recognized that sleep is essential for the maintenance of good health and is needed especially during the recovery process (Southwell & Wistow, 1995). Evans and French (1995) state that sleep is essential for energy restoration and physical healing during an illness. Roger Ulrich (2004), a leader in the evidence-based design movement, with a group of colleagues, has identified noise as a harmful factor in hospitals, concluding that most hospitals today are excessively noisy and that reducing noise could improve patient outcomes. In support of Ulrich's conclusion, a number of recent studies have found that that hospital noise is recognized as one of the main contributors to the loss of sleep and a source of dissatisfaction among patients and staff (Allaouchiche, Buflo, Debon, Bergeret, and Chassard, 2002; Bailey & Timmons, 2005; Busch-Vishniak, West, Barnhill, Hunter, Orellana & Chivukula, 2005; Christensen, 2005; Cmiel, Karr, Gasser, Oliphant and Neveau, 2004; Topf and Dillon, 1988; Topf, 1989; Topf, Bookman and Arand, 1996; Topf, 2000). Blomkvist and colleagues (2005) reported a study of the effects of acoustics on patient outcomes and found that patients in quieter rooms reported better sleep, lower stress, and were more satisfied with the nursing care than those subjected to noise. Lower re-hospitalization rates also have been associated with patients in quieter rooms, when

compared to their counterparts recovering in the less acoustically-sound rooms (Ulrich, Quan, Zimring and Choudhary 2004).

The sources of hospital noise are variable, dependent to some extent on the type of unit. For instance, Cmiel et al. (2004) in a study conducted at the Mayo Clinic, identified human activities and equipment-generated sounds such as IV-pumps, paging and intercom systems as the largest contributors to increased noise levels. Bailey and Timmons (2005) reported that activities such as opening/closing of sharps bins, cupboards, alarms, conversations and telephone receivers were found to be the loudest in a Pediatric Intensive Care Unit. In a survey of hospital patients, Southwell and Wistow (1995) reported that noise generated by other patients, nursing staff, telephones, conversations in the hallway, emergencies, flushing the toilet and corridor foot traffic were the most disruptive to their sleep.

Because most studies conducted on hospital sound levels find that reduction of hospital noise results in improved sleep and reduced stress levels (e.g., Johnson & Thornhill, 2006), measures need to be taken to reduce the amount of noise to which patients are subjected. While some noise contributing factors can only be addressed through operational changes, others can be dealt with through well-informed design applications.

A number of hospitals have taken measures to eliminate or reduce the noise stressor (Cmiel et al., 2004; Busch-Vishniac, et al., 2005). The Mayo Clinic, for example, after finding that noise levels exceeded the recommended levels, took initiatives to educate staff on noise issues and the importance of sleep, implemented new nursing procedures focusing on the reduction of noise and made physical adjustments to the unit.

After these changes were implemented, noise readings reflected a significant drop from the original (pre-intervention) readings. The same study reported that closing patient's room doors and nursing staff's increased awareness and cutbacks of their noise levels were the largest contributors to noise reduction. Patients surveyed after the changes were implemented reported a higher quality of sleep and satisfaction with the acoustics of the unit compared to those surveyed prior to intervention (Cmiel et al., 2004).

Recent research initiatives have focused on hospital noise pollution, using various methods such as the recording of noise levels, observation of an active patient unit and input from nursing personnel as well as the patients (Cmiel et al., 2004; Topf, 2000). While these studies reveal that noise can be a problem, recognizing that it needs to be managed is only the first step. In order to eliminate unnecessary noise, there needs to be a thorough understanding of its cause(s). Because the sleep and recovery of the patients is in question, their input is particularly valuable in identifying factors which contribute to elevated noise and loss of sleep. There is limited good data on specific noise-generating factors. An exception is the findings of the 1995 Southwell and Wistow study, but since it was conducted in England over a decade ago, it may not present an accurate account of the conditions in a US inpatient unit of today. Advancing technologies, new procedures and US standards may account for differences in the presence and assessment of noise pollution. Finally, while sources of noise are numerous, it is important to identify whether most occur at the room, corridor, or unit level, so that future design changes can focus on the most problematic zone(s).

The current study was originated by combining two approaches which examined noise-contributing factors in healthcare spaces. The first is found in an investigation by Southwell and Wistow (1995), designed to understand patient and nurse perceptions of noise-related factors. Another study was conducted by Cmiel et al. (2004) at Saint Mary's Hospital, a Mayo Clinic-affiliate in Rochester, Minnesota. Their project involved assessing noise levels in the department, identifying noise-contributing factors and using this information to implement interventions addressing areas of concern. Their recommended interventions were mostly behavioral in nature, with only minor environmental factors taken into consideration. A study conducted at Johns Hopkins Hospital (Busch-Vishniac, et al., 2005), however, implemented a design alteration (acoustical panels) in a hospital unit and used pre- and post-intervention sound level reading to evaluate the effectiveness of the change.

Each of these investigations contribute to the general understanding of the presence of noise in hospitals, the perception of noise by the staff and patients and implementation of basic solutions eliminating the problem of noise. Continuing the inquiry into noise-causing activities and factors, the current study investigated noise-contributing factors as perceived by the patients and further used that data to develop design recommendations for essential improvements in an effort to reduce noise.

CHAPTER II

REVIEW OF LITERATURE

General Findings Relating Sleep to Health

Sleep serves many functions. Several established relationships between sleep and health outcomes are presented in this study. Southwell and Wistow (1995) suggest that sleep is essential for good health and especially recovery from an illness. Other studies (Evans & French, 1995; Horne, 1988) indicate that sleep aids in energy restoration, which is especially significant during the process of recovery. Another possible link between sleep and health is found in the function of the immune system, and finally, in the wound healing process through renewal of damaged cells via protein synthesis and cell division (Adam & Oswald, 1984; Horne, 1988).

According to Horne (1988), tissues are renewed through the production of new cells which replace damaged or old cells. For instance, while skin cells are continuously shed, cell division produces new cells to replace those shed. A continuous process of degradation and renewal of bodily tissues occurs over a 24 hour period (Adam & Oswald, 1984). Degradation (catabolism) is caused by activities during the waking hours, while healing and restoration, (anabolism) through protein synthesis and cell division are aided by rest and sleep. Although the process of restoration is continuous throughout the

day, the rate of healing of the damaged tissues is greater during sleep (Adam & Oswald, 1984).

Links have also been established between sleep and mental functioning. For instance, as a part of the National Institute of Mental Health Epidemiologic Catchment Area study, Ford and Kamerow (1989) found that out of almost 8,000 respondents to an epidemiological survey at baseline and one year later, 46.5% of participants with sleep disorders such as insomnia and hypersomnia, also had a psychiatric disorder, compared to only 16.4% of participants with no sleep complaints.

Sleep Basics

Most noise-related investigations identify disruption of sleep as a primary consequence of excessive noise levels. To recognize why loss of sleep is a key focus, it is important to understand the essence of sleep and its importance on human well-being.

State of Sleep

In the state of waking, the brain is occupied with many functions; breathing is usually less regular and muscle and eye movement activity are heightened (Siegel, 2003). Sleep is defined as a natural state of rest characterized by unconsciousness from which a person can be aroused by external stimuli and decreased body movement. Sleep is characterized by the slowing of heart rates and breathing, as well as a decrease in blood

pressure and body temperature, and is termed non rapid eye-movement (NREM), or non-REM (Siegel, 2003).

Stages of Sleep

Sleep experts identify five stages of sleep. One stage is termed REM, or rapid eye-movement. The four other stages are levels of non-REM sleep, in which the body progresses into deeper states of sleep (Siegel, 2007).

The body enters the state of sleep through the first stage of NREM sleep. In this stage, a person's eyes are closed, there is less awareness of the surroundings, and the breathing starts to become more regular. This stage of sleep typically lasts from five to ten minutes at the beginning of sleep. Awareness of the surroundings is decreased further in the second stage of NREM sleep, but an individual is still relatively easily awakened. This stage is characterized by slowing of the heart rate, more regulated breathing and body temperature decrease. Stages three and four are the deepest sleep stages. Brain activity during these stages is slower, muscles are relaxed, breathing is very regular and it is extremely difficult to arouse. NREM stage four is also termed delta sleep (Bazil, 2005). After stages three and four, an individual enters REM sleep which is characterized by chaotic activity of the brain waves; the brain is very active in this stage, similar to that found in the state of wakefulness. However, there is no awareness of surroundings in REM sleep, instead, this is the stage where the body is normally paralyzed. It is also the stage where the majority of dreaming occurs (Bazil, 2005).

Although the stages of sleep are progressive, they occur in cycles throughout a person's period of sleep. On average, an adult goes through three to five REM periods in one night; the rest, or about 80% of time spent sleeping is NREM sleep. Each state is essential for the human body, as different biological purposes are served in the various stages. In adults aged 20-60, these stages occur in continuous, usually 90-minute cycles (Siegel, 2003).

Sleep is generally affected by factors such as age, gender and various health conditions, therefore, the amount and quality of sleep varies between individuals (Redeker, 2000). Newborns spend 17-18 hours sleeping. From that point, the amount of sleep continually decreases, and a young adult requires about eight hours of sleep per day to function optimally during waking hours (Siegel, 2003). Older adults experience less deep sleep, therefore, their sleep is more easily interrupted than their younger counterparts. After the age of 65, total sleep increases slightly, however, older adults have more difficulty falling asleep, their sleep is more shallow and fragmented; elderly people awaken more frequently and tend to stay awake longer (Siegel, 2003).

Noise as a Major Source of Sleep Disturbance

While it is difficult to establish a definitive cause and effect relationship between physical factors of a space and an individual's health outcomes, various physical features have been linked to human performance through careful investigations. A range of factors such as natural light (Anjali, 2006), real and simulated views of nature (Parsons &

Hartig, 2000; Ulrich, 1984), and temperature controls and noise levels (Busch-Vishniak, et al. 2005; Cmiel et al., 2004; Topf, Bookman and Arand, 1996), have been found to directly affect human biological functions and the process of recovery. While some of these factors positively affect patients' physical performance, others are sources of aggravation or disturbance and can cause stress and other negative reactions. Elevated noise levels have been found to disturb sleep and cause elevated levels of stress (Cmiel et al., 2004).

Sound Basics

Sound is produced by a vibration of any object in a medium such as air or water. The vibrating action creates disturbances of the medium, thereby causing waves to travel through it and reach the human ear (Cmiel et al., 2004). Because sound is a wave, it has two main characteristics, frequency and amplitude. The human ear is sensitive to both frequency and amplitude or loudness, of sound waves.

Frequency

Sound frequency is defined as the speed at which the air particles vibrate (Cmiel, 2004). Frequency is a measure of how many vibrations occur in one second and is measured in units called Hertz (Hz), where 1 Hz = 1 vibration per second. The ear of a healthy young adult is typically able to perceive frequencies from about 20 Hz to 20,000

Hz, which fall below the lowest of the 88 piano keys (27 Hz) and above the highest notes of a piccolo, the highest orchestra instrument (Lang, 1994). Sound frequency directly correlates to its pitch, where low frequency sounds such as the low piano keys or strings of a contra-bassoon have longer wavelengths (distance between the crests of two consecutive waves, refer to Figure 1), and result in a 'low pitch'. Pitch heightens (increases) with the decrease of the wavelength period, as shown in Figure 1, resulting in sound such as that of a piccolo, which is considered a 'high pitch' (Lang, 1994).

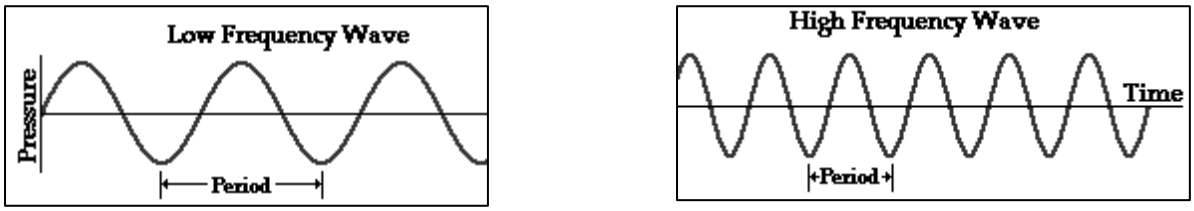

Figure 1. Frequency of sound waves (Henderson, 2007).

Amplitude

The amplitude of sound, also referred to as volume and loudness, is the physical pressure exerted on the ear drum by the vibrating particles of air (Cmiel et al., 2004). This is measured in units called decibels (dB) using a logarithmic scale based on multiples of ten. As the loudness of sound increases, the crest or height of the wave is increased (see Fig. 2), although, the distance between the waves (its frequency) may not be affected. Thus, a low frequency sound may be either very loud or very soft, just as a high frequency sound may be very loud or very soft.

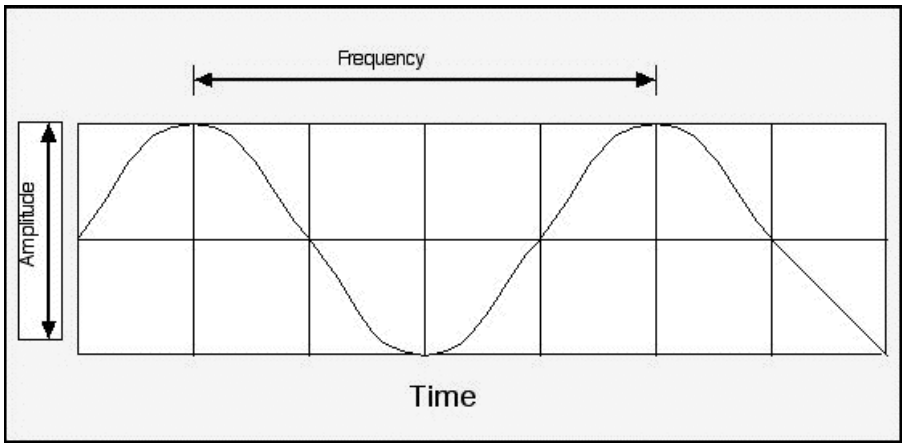

Figure 2. Basic components of a sound wave - amplitude and frequency (Henderson, 2007).

Sounds found in the environment are measured in dB units. Figure 3 provides approximate decibel levels of common noise sources. Because perceived loudness of sound is dependent on factors such as the ear's sensitivity to sound at different frequencies, a weighted unit of sound intensity was developed. This scale registers dB(A) or 'a-weighted' decibels (Cmiel et al., 2004). The threshold of hearing by the human ear is 0 dB, where no sound is perceived at all. The threshold of pain in an adult from the intensity of sound is 130 dB, which is 10 trillion times more intense than a sound at the threshold of hearing.

Sound Pressure Level (dBA)	Noise Source
140	Jet Engine (at 25 meters)
130	Jet Aircraft (at 100 meters)
120	Rock and Roll Concert
110	Pneumatic Chipper
100	Jointer/Planer
90	Chainsaw
80	Heavy Truck Traffic
70	Business Office
60	Conversational Speech
50	Library
40	Bedroom
30	Secluded Woods
20	Whisper

Figure 3. Decibel levels of common noise sources (Minnesota Pollution Control Agency, 1999).

Sound and Noise

Christensen (2005) defined noise as any sound that causes subjective annoyance and irritation, is unwanted, undesirable, without musical quality and disruptive to performance. There is no objective dB level at which sound becomes recognized as noise. However, Andren, Hansson, Bjorkman and Jonsson (1980) state that changes in physiological functioning become significant at levels of 70dB and above, causing disturbance of patient sleep, increased need for pain relief medication and elevated cardiovascular functions.

Effects of Noise on Health

Noise is a recognized stressor and causes psychosocial responses such as annoyance, sleep disturbance and physical responses (Cmiel et al., 2004; Hweidi, 2007; Topf and Dillon, 1988; Van Kempen et al., 2002). Studies reveal that aside from obvious annoyance, adults report physical symptoms as a result of elevated noise levels. These include increased stress levels, increase in blood pressure and heart rate, as well as sleep deprivation (Ulrich, et al., 2004).

Some studies have reported a connection between noise and health conditions, such as heart disease in human subjects. For instance, over 4000 heart attack survivors in Germany were involved in a study evaluating their daily noise exposure in the years preceding the heart attack (Willich, 2005). A control group was used consisting of patients from the same hospitals who did not report heart attacks in their history. Standardized bedside interviews asked all participants to rate their environmental noise exposure during the recent years on a scale of 1 to 5, with 5 being extremely annoying and 1 - not bothersome at all. The study revealed that patients with chronic exposure to noise were 'mildly to moderately' more likely to develop a heart attack. While this does not prove that noise causes heart attacks, it may reveal that there is a link between heart attacks and noise exposure.

Van Kempen and colleagues (2002) conducted a review of all studies on exposure to noise and blood pressure and ischemic heart disease between 1970 and 1999, a total of 79 studies. Their conclusions state that exposure to occupational noise was related to

increases in the systolic and diastolic blood pressure. They also found that small, transient noise levels were associated with shifts in blood pressure and may lead to an increase in diagnosed hypertension and medication use.

Other studies have also indicated that increased noise adversely affects patient health. Higher noise levels have been found to result in decreased oxygen saturation, increased blood pressure, increased heart and respiratory rates and worsened sleep in infants (Johnson, 2001). Studies conducted on adult patients found that heart rates increased with the increase of sound levels (Baker, 1992; Baker, Garvin, Kennedy and Polivka, 1993).

Sleep Disturbance Affecting Health and Recovery in Hospital Settings

Noise Levels in Hospitals

The goal of any environment is to achieve a harmonious compatibility with its user; person-environment compatibility is present when the physical environment allows necessary functions to take place with a minimal presence of stressors, when the goals and needs of the user are met. Sleep is a natural and essential function which must occur in a hospital patient room. According to a number of recent studies (e.g., Cmiel et al., 2004; Christensen, 2005; Hweidi, 2005), however, the hospital environment doesn't always promote sleep, instead presenting sleep-disturbing stressors.

Many factors may account for sleep disruption in hospitalized patients. These include underlying illness, uncomfortable medical procedures and monitoring interventions, mechanical ventilation and environmental factors including temperature, light and noise (Stanchina, Abu-Hijleh, Chaudgry, Carlisle and Millman, 2005). Through decibel noise recordings and observation, Allaouchiche and colleagues (2002) found that staff conversations accounted for elevated noise, as well as alarms, telephones and the practices of the delivery of care.

A large number of research investigations present evidence that noise present in hospital settings is often excessive, unnecessary and harmful (Bailey & Timmons, 2005; Baker, 1992; Bazil, 2005; Busch-Vishniac, et al., 2005; Cmiel et al., 2004; Topf, 1988; Topf, bookman and Arand, 1996). In 1974, The Environmental Protection Agency developed noise level recommendations indicating that in a hospital, noise levels should not exceed 45 dB(A) during the day and 35 dB(A) during the night. These decibel readings are similar to a quiet woodland setting and a library. In 1993, attempting to improve hospital noise levels, the World Health Organization (WHO) developed guidelines recommending that the levels of noise should not exceed 40 decibels during the day and 35 decibels at night (World Health Organization, 1993). In 1995, WHO released Guidelines for Community Noise, further decreasing the acceptable levels of noise in patients' rooms. Specifically, the WHO recommended sound levels during the day to be no greater than 35 dB and 30 dB at night (Berglund and Lindavall, 1995).

Bailey and Timmons (2005) recorded sound levels generated by various equipment and activities in a Pediatric Intensive Care Unit over a period of 12 hours.

During the period of this study, sounds ranged from 50 to 83 dB. Opening/closing of sharps bins, cupboards, alarms, conversations and telephones were found to be the loudest.

Overall, staff conversations and equipment noise such as alarms have been found to be most disruptive to the patient. One study, focused on conversation noise generated in and outside of the room, found that patients' heart rates increased significantly more in response to noise generated by conversations than to ambient and non-conversational noise (Baker, 1992).

Topf, Bookman and Arand (1996) in a laboratory simulation of noises found in a Critical Care Unit (CCU) found that adult female subjects reported taking longer to fall asleep, awakened more often, had a poorer quality of sleep and overall experienced less deep sleep than the subjects in a quiet control group. In another study, Bazil (2005) reported that 10 to 40 percent of the arousals recorded in the ICU were linked to the increased presence of noise.

Efforts to Reduce Noise Levels

Based on the findings of many different investigations that focused on increased noise levels being disruptive to patients, a number of hospitals have begun addressing the presence of environmental noise. Ulrich et al. (2004), in his analysis of scientific studies states that in hospitals that cut noise levels, it has been found that patients slept better,

had lower blood pressure, were less likely to be re-hospitalized and were more satisfied with their care.

Effects of Noise on Health

Deprivation of sleep is associated with a range of negative health effects. While it is difficult to find a definitive cause-and-effect relationship between sleep deprivation and physical symptoms, various studies report that certain behavioral and physiological changes are consistent with poor quality of sleep. For instance, sleep deprivation is believed to delay the healing process, specifically, the speed of wound healing, which in turn lengthens hospital stays (Adam & Oswald, 1984; Busch-Vishniak et al., 2005; Reid, 2001). One reason suggested for this is that adrenaline, released due to stress during the waking hours, prevents cell division necessary for healing (Bullough & Lawrence, 1966). Delayed healing has also been linked to the loss of sleep, specifically, through diminished protein synthesis and immune function, which interferes with cell repair (Horne, 1988).

In their 1995 study, Southwell and Wistow investigated sources of sleep disruption of hospital patients at three different sites. They found that 50% of participants had difficulty sleeping through the night and did not get as much sleep as they needed during their hospitalizations. This study related sleep disturbances to a total of 14 factors (11 of which represented hospital environment factors), including noises generated by other patients, the ringing of the telephone, nurses' conversations, emergencies in the unit, flushing of toilets and foot traffic in the corridor.

Unnecessary arousal from sleep is often caused by excessive sound levels in a hospital. Through responses of a patient survey, Aaron and colleagues found that noise is disruptive to sleep (Aaron, Carlisle, Carskadon, Meyer, Hill and Millman, 1996). Webster and Thompson (1986), in an observational study of patients found that noise and pain were the primary causes for sleep deprivation. Pain was ranked as the factor most responsible to sleep, with noise being the second most reported cause for sleep disruption.

In 2004, Cmiel and her colleagues conducted a study testing the levels of noise at the Mayo Clinic. Continuous night shift recordings of sound in dB(A) were obtained without the knowledge of the staff in three private patient rooms. A participating RN observed the rooms from the nurses' station and recorded activities to correlate them to decibel readings. On a second night, sounds were recorded in a semi-private room. Although the room was empty, all normal activities involved in caring for two post-surgical thoracic patients were simulated. The data revealed that human activities such as walking and conversations and equipment were the largest contributors to increased noise levels. Decibel readings in the empty private patient rooms averaged at 45 dB(A). In semi-private rooms with activities being simulated to reflect normal activities, the average noise reading was 53 dB(A). Peaks reached 113 dB(A), an equivalent to the sound generated by a chainsaw/leaf blower.

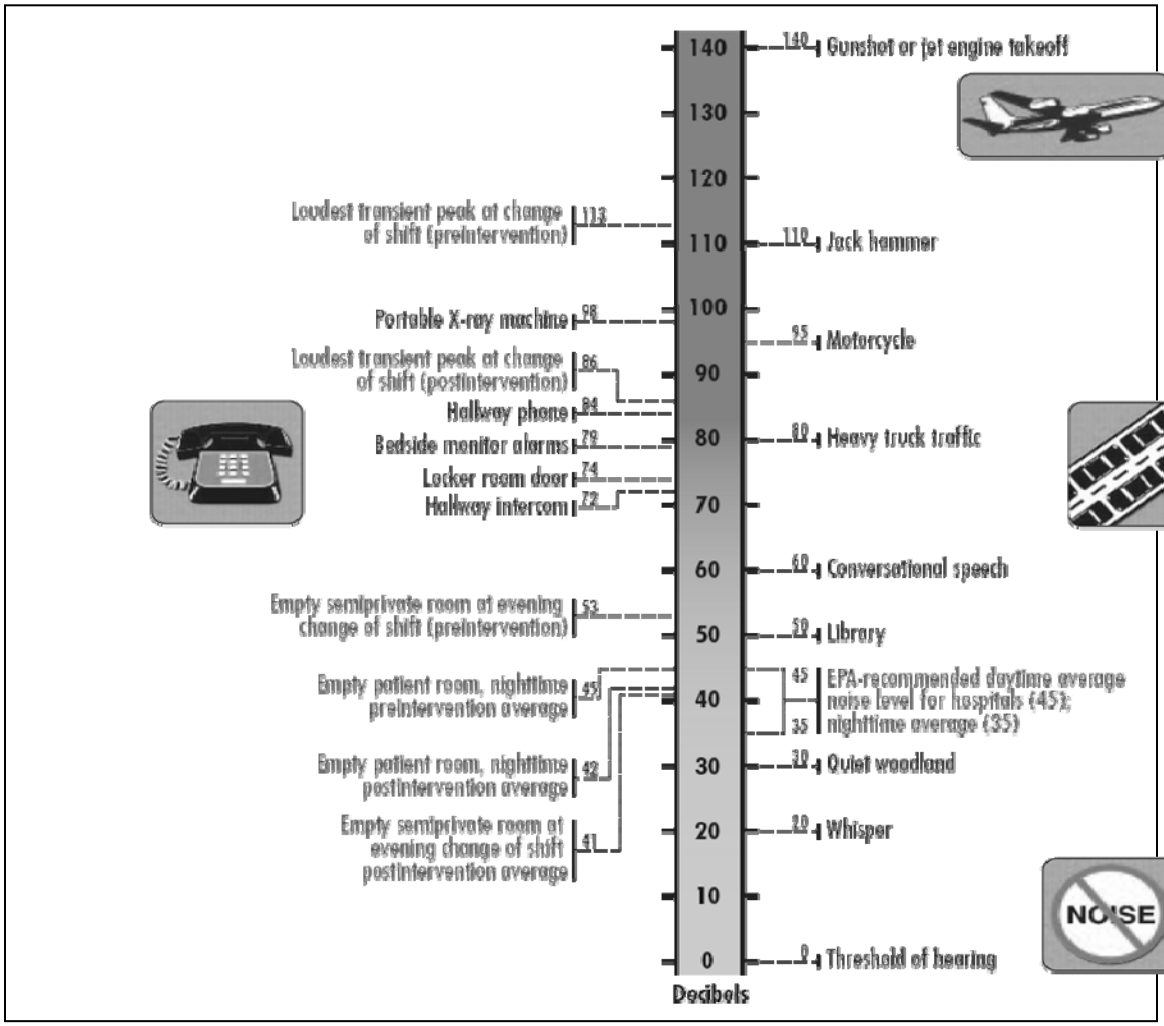

Figure 4. Decibel levels of noise sources found by Cmiel et al. (Cmiel et al., 2004).

Intervention to Reduce Noise Levels in Hospitals

A follow-up stage of the 2004 Cmiel et al. study involved implementation of a set of recommendations based on findings from the first stage of the study. These included

closing patient room doors, turning the TV and alarm volumes down and limiting the use of overhead paging. Patients who were not in need of night-time care were identified and the staff was instructed to limit nursing care at night. An educational program also was presented to the nursing and ancillary staff stressing the importance of speaking softly and limiting the amount of time spent in conversation. Equipment (cardiac monitors and pneumatic tube systems) and furnishings (chart holders and paper-towel dispensers) were also modified to help decrease the noise.

After these changes were implemented, researchers found that closing the patient room doors and increased awareness of the noise levels were the largest contributors to noise reduction. Noise readings in an empty private room decreased by only 3 dB(A) from peak readings, however, noise readings decreased significantly to 86 dB(A), compared to the pre-intervention peak reading of 113 dB(A). Patients were surveyed about the quality of their sleep after the interventions were implemented. Of 90 comments related to noise and sleep, 65.6% were positive; patients were very pleased with being able to close the door at night and the general quietness of the unit (Cmiel et al., 2004). Figure 4 reflects the pre- and post-intervention noise readings at the Mayo Clinic, and compares them to actual sound levels of everyday life, illustrating, for instance, that the noise from bedside monitor alarms was only 1 dB lower than heavy truck traffic.

Simple design considerations such as material choices can significantly influence the well-being of the patient. The Busch-Vishniak et al. (2005) experiment at Johns Hopkins Hospital compared noise levels in patient areas before and after installing acoustical panels in parts of the unit where increased sound activity occurs, such as nurses' stations.

Units with acoustical panels recorded much lower sound levels than those without panels. This seemingly simple application was found to have a marked impact on the presence and perception of noise for the patients, particularly, in efforts to reduce noise (Busch-Vishniac, et al., 2005).

Conceptual Framework for Identifying Noise Sources that Disturb Sleep

Investigators have revealed relationships between environmental factors and physical and/or psychological effects on human subjects. In 1983, Kaplan stated that person-environment compatibility exists when the physical surroundings facilitate meeting the needs and goals of their occupants. In an effort to gain a fuller understanding of the relationship of people with their environment, Topf (2000) developed an Enhancement of Person-Environment Compatibility model, incorporating all factors which affect human health, including ambient stressors (see Figure 5). Predicting that stress leads to negative health outcomes, this model describes how people react to stressors and what can be done to prevent stressors from causing stress.

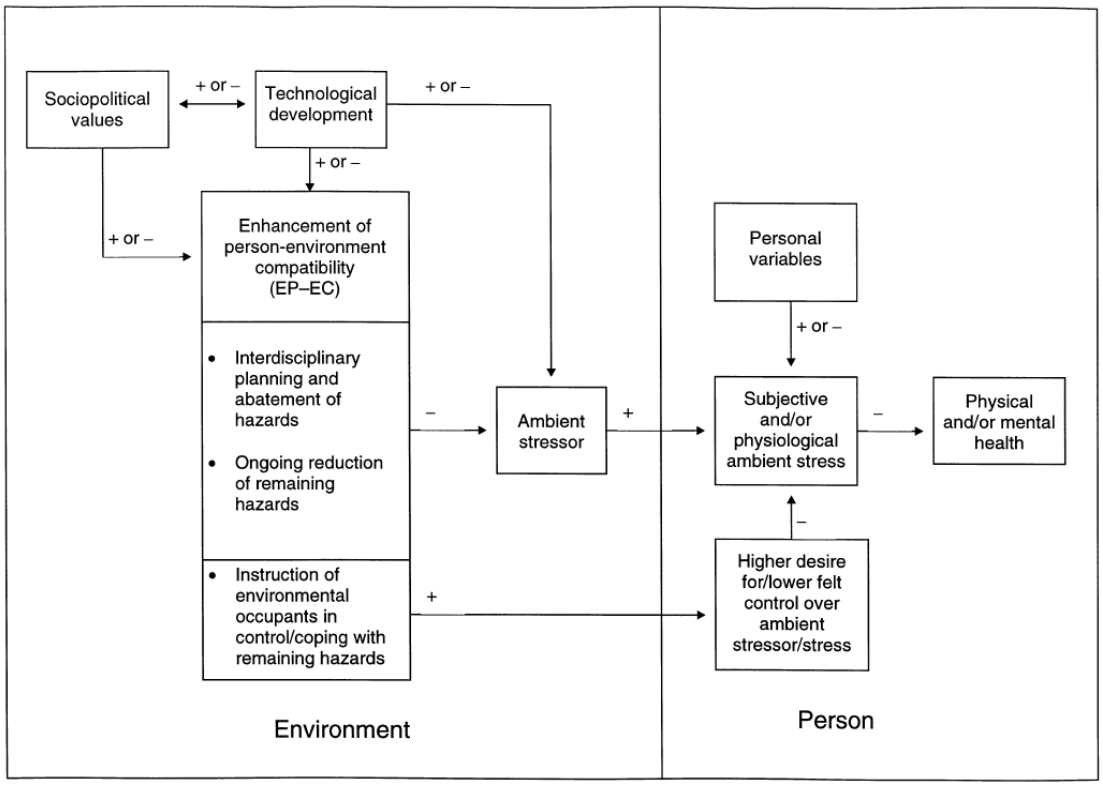

Figure 5. Enhancement of Person-Environment Compatibility model. (Expanded from Topf 1984, 1994).

The model postulates that factors such as sociopolitical values and technological developments influence the compatibility of people and their environments. For example, political values of the society can affect government regulations and standards which would allow fewer environmental stressors. Technological advancements can contribute to reduction or increase in the presence of stressors. For instance, an increase in bedside equipment contributed to excessive CCU sound levels; on the other hand, older, noisier equipment may be replaced with silent models, therefore reducing the presence of stressors. To enhance person-environment compatibility (EP-EC), measures can be taken to

reduce hazards and provide users with ways to cope with existing hazards. Ideal intervention would prevent the presence of stress, however, hazards which cannot be prevented are recognized as stressors, and lead to subjective and/or physiological ambient stress.

The perception of stress also is influenced by personal variables such as a person's sensitivity to specific stressors, personal and cultural preferences such as perceived social support, stage of life, gender, or a desire for a quiet or solitude. Stress may be controlled further by one's desire and ability to control stressful factors. Topf concludes that the presence (or elimination) of stress, influenced by personal variables, sociopolitical values, ability to control the stressors and technological developments, affects physical and/or mental health.

Hospitals are extremely complex physical environments with a high presence of stressors caused by a range of factors. In the context of Topf's model, recent work by Hweidi (2007), Topf and Dillon (1988) suggests that excessive sound levels may be considered as environmental stressors. Using a patient questionnaire, for example, Hweidi (2007), found that buzzers and alarms were one of five major stressors within a hospital room. Topf (1996) found that subjects exposed to noise recorded in the CCU reported poor qualities of sleep. In order to enhance the compatibility of the patient and their environment, excessive sound levels (also termed noise) should be eliminated from the hospital environments. Identifying specific stress-causing noise factors is the first step toward eliminating noise and restoring person-environment compatibility. Thus, this part of the model was the focus for the current study.

Complexity of this model is necessary to explain a wide range of variables controlling the physical outcome of the patient. While all factors are important for a thorough understanding of human interaction with the environment, the current study is developed on the postulation that environmental ambient stressor (noise, in this case) has an effect on the physical and/or mental health of the patient. Using Topf's model as a basis, this study focused on only two elements, as is shown in Figure 6, where the ambient stressor of noise is the independent variable, with the patient's health outcome being the dependent variable. Specific factors of the physical environment were identified and reviewed, in an effort to create a more appropriate environment which would support the patient's needs.

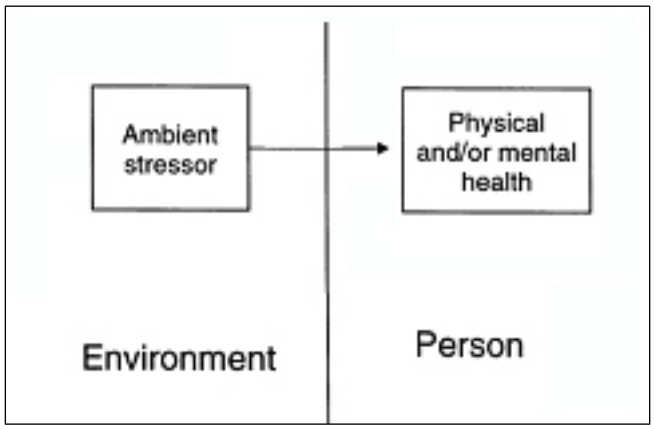

Figure 6. Abbreviated version of Topf's EP-EC model

Summary Conclusions

Hospitals today are recognized as having excessive sound levels (Busch-Vishniac, et al., 2005; Cmiel et al., 2004; Topf, 2000). Equipment, foot traffic, conversations and other factors disrupt sleep necessary for patient recovery and contribute to elevated levels of stress (Cmiel et al., 2004). Recently many research initiatives attempted to understand and improve the physical environments in healthcare. From the extensive review of literature available on noise levels and sleep patterns of hospitalized patients, the following can be said about this study. Noise is a stressor common to hospitals, and unless positive interventions are used to prevent it from reaching the patient, noise can cause unnecessary stress, negative physiological reactions and deprivation of sleep. Since sleep is an essential element of tissue healing and energy restoration, measures should be taken to protect patient sleep. Common factors such as conversations, foot traffic and equipment noise account for the majority of noise-related complaints, and finally, hospitals which have taken measures to reduce the presence of noise and improve patient sleep recorded higher patient satisfaction, lesser occurrences of negative medical conditions and re-hospitalization. These findings stress the importance of a more thorough understanding of hospital noise and sleep, and are encouraging in enhancing the person-environment compatibility.

As this review suggests, it is not enough to be aware of the problem of noise; the problem can only be rectified through understanding the underlying causes and identifying constructive ways of eliminating it at its source. With an increased

understanding of the sources of noise that threaten patients' sleep, healthcare designers will be able to generate recommendations for successful solutions to the enhancement of person-environment compatibility.

CHAPTER III

METHODOLOGY

Instrument Development and Description

Sources of sleep-disturbing noises were identified through a patient survey (see Appendix A). The survey was developed based on items from previous work investigating noise and other factors contributing to sleep disruption/disturbance among hospital patients (Cmiel et al., 2004; Southwell & Wistow, 1995), input from the nursing staff and observation by the study's author.

The survey was designed to enable patients to easily identify specific noise-causing features and activities taking place in the wing block/unit. A list of 38 items provided patients an opportunity to check specific factors they felt were disturbing to their sleep. Twenty-five of those factors were noise-related, and 13 represented other environmental factors commonly found to be disruptive to sleep. Respondents also were asked to identify factors other than those listed as an open ended question. Finally, they were asked their age, gender, hospital room number, length of stay, whether they had any hearing impairments and if they had surgery during this admission (which might indicate high sedative medication levels).

Site Description

Moses H. Cone Memorial Hospital was selected based on its accessibility, location, type of patients admitted and willingness to participate in the investigation. Managers of three departments with overnight populations agreed to allow their units to participate in the study. The three department/units were: the Orthopedic Unit (wing block 5000), the Medical/Renal Unit (wing block 5500), which was temporarily relocated (wing block 5100), and the Medical/Surgical Unit (wing block 5700). All three units are located on the fifth floor of the main building. Completed in 1953, this first building of the Moses H. Cone Memorial Hospital has undergone a number of reconstruction phases.

The Orthopedic department population includes patients with hip and knee replacements, and a wide variety of fractures and traumatic injuries. The physical unit consists of 40 private inpatient beds, a centralized nurse station, and a physical therapy gym. The Medical Renal wing block consists of 14 private, six semi-private and two isolation rooms. This unit provides care for patients with a variety of renal diseases, gastro-intestinal bleeding, hyperkalemia (high levels of potassium circulating in the blood), fluid overload, and diabetes mellitus (increased blood sugar levels). Finally, the Surgical wing block consists of 22 private and nine semi-private rooms and holds patients recovering from a variety of exploratory surgeries, mastectomies, eye surgeries, hemi-cholectomies and other types of surgical procedures, both inpatient and overnight observation, as well as medical overflow patients.

Sample Population

Convenience sampling was used in this study. The following criteria were used to select and recruit participants for the study. All participants had to be patients who were:

1. Cleared for discharge from care
2. Been in the hospital for at least 24 hours
3. English-speaking
4. 21 years or older
5. Deemed competent and able to complete the survey by the discharge nurse.

Patients meeting these criteria were approached by the researcher and invited to participate in the study. Patients willing to participate were given a brief description of the study and then asked to read and sign an Informed Consent Form (see description of page 1 of the survey below). Participation was entirely voluntary. The first page of the survey invited the patients to participate and contained descriptive information about the study. It explained the purpose, what precautions have been taken to maintain confidentiality, the benefits and risks which may be involved, as well as contact information for any questions or concerns. It stated that by returning the completed survey, patients gave their consent to participate in this study.

Data Collection Procedure

The survey was self-administered and took approximately five to ten minutes to complete. Some of the patients requested that the survey be read to them, rather than their filling it out themselves.

The researcher was available to collect data on Tuesday, Thursday, Saturday and Sunday mornings. Each morning patients due for discharge were identified by nursing personnel. Surgical patients were available for the survey between 9:00 and 10:00 am and general medical patients were typically processed for discharge from 11:00 to 12:00pm. Orthopedic unit patients had the latest discharge of the day as they go through a round of physical therapy prior to leaving the hospital. These times were identified by nurse managers as ideal for administering the questionnaire with minimal interruptions of the medical functions.

On the mornings that the researcher was in the hospital to collect data she checked with the nurse on duty and was given a list of rooms with patients identified for discharge and capable to participate (study inclusion criterion #5). Each patient was approached individually, and given a brief description of the study and its purpose. Patients were able to decline or agree to participate, or request that the survey be administered verbally. Upon the patient's agreement to participate, the researcher left the survey and a pen with the patient and returned in 10-20 minutes to check on the progress or answer any questions. Completed surveys were collected by the researcher and responses were

entered into a spreadsheet; all forms were kept in a secure location. Survey data were collected over a six-week period.

Data Analysis

The data analysis focused on achieving two objectives: (1) identifying sources of noise reported to cause sleep disruption by patients in the three hospital wings and (2) determining if the patient characteristics of gender, age, surgery experience, and hearing impairment are associated with differential reports of sleep disturbance and the sources of noise identified as casual factors of sleep disturbance.

The responses from the questionnaires were analyzed to answer the following research questions:

1. What are the most frequently identified sources of noise causing sleep disruption reported by the sample (measured by the count of respondents who gave the source a rating of either "a little" or "a lot" influence)?
2. Which identified sources of noise causing sleep disruption were identified more frequently by the sample (measured by the mean rating of influence)?
3. Were there differences in sleep disturbance reporting for sources that were patient- mechanical (i.e., equipment) vs. patient-medical/operational (i.e., bed checks, nurse doctor conversations) vs. external environmental (i.e., corridor traffic, music, conversations outside the patient room)?

4. From what location (bedside, room, corridor, or other) do the most sleep disruptive noises emanate?
5. What time of day was identified as the time period in which the most sleep disruptive noise occurs?

These five questions were examined in relationship to the four patient characteristics identified in Objective 2. In addition to the noise sources other factors that may have disturbed the respondent patients' sleep, included: (a) lighting in your room, (b) lighting in corridors, (c) comfort of your bed, (d) pillows, (e) odors, (f) room temperature, (g) nursing and medical intervention, and (h) medical procedures were assessed. The incidence of these non-noise factors were examined to determine if their frequency of occurrence and degree of sleep disturbing effects were similar to those of the noise sources.

CHAPTER IV

RESULTS

Sample Description

Over the course of the six week data collection period a total of 102 patients in the three units were asked to participate in the study. Of the sixty-one respondents (60% participation rate), 42% were male and 58% female. A majority (68.8%) of the patients' stays involved a surgery. Ten patients reported having a hearing impairment. Ages of respondents ranged from young adult to the elderly, with 52% being under the age of 50 and 48% being fifty years of age and over. 46% of the respondents reported having the most difficulty sleeping during the night hours.

Organization of Results

The noise factors identified by participants are subdivided into noise and non-noise related categories. Since the purpose of this study focused on noise-related items and behaviors, an emphasis will be placed primarily on analyzing the results from the noise category. For the purposes of analysis, 'a lot' and 'a little' categories of responses have been combined.

Noise-Related Environmental Factors

Examination of the findings reveal that out of 33 listed factors (25 noise-related, and 8 miscellaneous), 17 were reported as disruptive to sleep by at least one-third of the respondents.

Table 1. Responses to Sleep-Disruptive Factors Reported by at Least One-Third of the Sample

			Extent Respondents' Sleep Was Disturbed					
			A Lot		Some		None	
		Total N	N	Percent	N	Percent	N	Percent
NOISE SOURCES								
Bedside	Beeping of IV pump / monitor	61	24	39	21	34	16	26
	Phone ringing	59	7	12	15	25	37	63
Room	Intercom paging system	60	9	15	27	45	24	40
	Nurse coming into the room	61	16	26	20	33	25	41
	Med cart rolled into the room	60	3	5	20	33	37	62
	Nurse/doctor conversations	60	8	13	15	25	37	62
Corridor	Nurse/doctor conversations	53	13	25	16	30	24	45
	Staff activity (charting station/binders, etc.)	51	7	14	15	29	29	57
	Rolling carts, equipment	53	5	9	15	28	33	62
	People walking	54	6	11	14	26	34	63
	Intercom paging system	52	5	10	13	25	34	65
OTHER ENVIRONMENTAL FACTORS								
	Comfort of your bed	60	14	23	20	33	26	43
	Nursing and medical intervention	58	10	17	19	33	29	50
	Room temperature	59	7	12	19	32	33	56
	Pillows	60	9	15	17	28	34	57
	Medical procedures	55	7	13	16	29	32	58
	Lighting in your room	60	7	12	14	23	39	65

Noise-Related Factors

Table 2. Frequency of Noise-Related Sleep Disruptive Factors

NOISE SOURCES		Total N	Extent Respondents' Sleep Was Disturbed: A lot / Some N	A lot / Some Percent	None N	None Percent
Beeping of IV pump / monitor (bedside)	Bedside	61	45	74	16	26
Intercom paging system	Room	60	36	60	24	40
Nurse coming into the room	Room	61	36	59	25	41
Nurse/doctor conversations	Corridor	53	29	55	24	45
etc.)	Corridor	51	22	43	29	57
Med cart rolled into the room	Room	60	23	38	37	62
Nurse/doctor conversations	Room	60	23	38	37	62
Rolling carts, equipment	Corridor	53	20	38	33	62
Phone ringing	Bedside	59	22	37	37	63
People walking	Corridor	54	20	37	34	63
Intercom paging system	Corridor	52	18	35	34	65

Eleven of a total of 17 factors most frequently identified by the patients were noise-related (see Table 2). Of those, four items were equipment-related in nature – (1) the beeping of the IV pump, (2) equipment being rolled in the corridor and (3) wheeled into the room and (4) telephone ringing. Most common operational/behavioral complaints were the intercom paging of the staff, nurse and doctor conversations, staff activity in the corridor, nurse coming into the room, medical procedures and nursing intervention.

Of most-frequently identified noise-related factors, two were located at patients' bedside, four found within the patient's room, and five from the corridor.

Miscellaneous Factors

Six out of eight non-noise related factors were identified by at least one-third of the respondents to be disruptive of their sleep (see Table 3).

Table 3. Responses to Non-Noise Related Environmental Factors

		Extent Respondents' Sleep Was Disturbed			
		A lot / Some		None	
NOISE SOURCES	**Total N**	**N**	**Percent**	**N**	**Percent**
Comfort of your bed	60	34	57	26	43
Nursing and medical intervention	58	29	50	29	50
Room temperature	59	26	44	33	56
Pillows	60	26	43	34	57
Medical procedures	55	23	42	32	58
Lighting in your room	60	21	35	39	65

Of these factors, the ones contributing to the most frequent sleep disruption were operational/behavioral in nature (nursing/medical intervention and medical procedures); comfort of the bed is an equipment/furnishing issue. Room temperature and lighting-related complaints fall into the category of design technologies and controls. Pillows were reported to contribute to the loss of sleep by 42% of the respondents.

Statistical Analyses

All comparisons of frequency data were tested using chi-square tests (used to evaluate statistically significant differences between proportions or groups in a data set). This was done to test Research Question 1. The main objective was to determine if there were group differences based on gender, age, surgery experience, and hearing impairment.

The results indicate that very few differences in responses between the age groups, gender groups, hearing capabilities, length of stay or between those whose stay was surgery-related or not. Table 4 presents a summary of results by the following characteristics: age, gender, hearing impairment, length of stay and involvement of surgical procedures for which a statistically significant difference was found. Because there were few significant differences, these results are included mainly as a means for exploring potential important relationships of the characteristics of the sample to the sleep environment factors examined in this study. The level of .10 was selected because of the exploratory nature of this analysis.

Table 4. Percent of Respondents Reporting Disruption of Sleep by Respondent Characteristics

	VARIABLE	RESULTS				CHI SQUARE	P VALUE
		N	%	N	%		
C2	Nurse/doctor conversations by length of stay	1-2 nights		3+ nights			
		34	44.1	19	73.7	4.30	0.048
R1	Intercom paging by gender	female		male			
		35	74.3	25	40	7.14	0.015
R1	Intercom paging by age	< 50		50 +			
		31	74.2	29	44.8	5.38	0.034
R5	Nurse/doctor conversations by hearing impairment	yes		no			
		10	10	50	44	4.08	0.073
C2	Staff activity by hearing impairment	yes		no			
		6	16.7	47	59.6	3.95	0.080
M4	Pillows by gender	female		male			
		35	54.3	25	28	4.10	0.064
M3	Room temperature by surgery	yes		no			
		43	48.8	17	76.5	3.79	0.082

Statistical analysis of the differences revealed the following:

1. Respondents with hospital stays of three or more nights were significantly more likely to report nurse/doctor conversations disrupting their sleep than respondents who stayed only one or two nights.

2. Female respondents were significantly more likely to report having their sleep disturbed by intercom paging within the room then their male counterparts.
3. Intercom paging within the room was significantly more likely to disrupt the sleep of respondents under the age of 50, than the group of respondents ages 50 and over.
4. Respondents with a hearing impairment were less likely to report to have their sleep disrupted by nurse/doctor conversations in the room than respondents who reported having no hearing impairments.
5. Respondents with hearing impairments were less likely to report that staff activity in the corridor disrupted their sleep then their counterparts without a hearing impairment.
6. Female respondents were more likely to state that pillows contributed to their discomfort and disruption of sleep than male respondents.
7. Respondents who had a surgery involved in their stay were more likely to report that room temperature contributed to the poor quality of sleep than respondents who did not have surgery.

CHAPTER V

DISCUSSION

General Findings

Seventeen sources of moderate to high sleep disturbance were identified by the survey respondents. Of these, 11 were noise-related and six were non-noise related environmental factors and behaviors. Two of the noise factors were located at bedside (IV pump and telephone ringing), four emanated from inside of the room, and the remaining five occurred in the corridor and were transmitted into the room.

Even though the corridor is the furthest removed zone from the patient, the study revealed that the factors most disturbing to patient sleep tended to enter from this source area. Because of the high activity in the corridor the finding that most sources of noise would arise from that area makes sense. In conversation with the investigator, individual respondents revealed that those who were able to keep their door closed had significantly fewer complaints about the noise conditions in the corridor than those who had to keep their door open.

Comparing the results of this study with those of Southwell and Wistow's (1995) study, certain trends are evident. For instance, telephone ringing and nurse conversations were identified as highly-disturbing factors in the Southwell study, which is consistent with the current investigation. Noises coming from other patients and nurses attending to them

(such as emergencies on the ward reported by Southwell) were at the top of the list, confirming that individual patient rooms must be insulated and protected from noises happening outside of the immediate patient environment.

Again, supporting the findings of this study, comments gathered from patients and staff in the Cmiel et al. (2004) study reveal that staff conversations, IV pumps, paging and intercom systems were in need of adjustment to ensure a quiet environment, promoting sleep. Observers in the Kahn et al. study (1998) identified talking to be the most highly disruptive noise factor in the Intensive Care Units in a Providence RI hospital.

It's important to note that the findings of the current investigation are consistent with the previously established results. While the studies mentioned incorporated a variety of methods to identify noise-generating factors and have identified other factors as well, there are evident similarities between these studies. The differences in findings may be a result of differences between hospital operations and design, methods of collecting information and the focus of each study.

Patient Comments

In addition to completing the provided survey, some patients offered comments to explain their survey responses. While bedside sleep disturbances were noted by many respondents, the only patient comment relating to bedside noises was a suggestion to use light-indicators on the IV pump system rather than the beeping by a patient who reported that IV pump beeping was the only highly disturbing noise in her experience. Noises at

the room level received more comments from participants. One respondent who found it particularly difficult to sleep reported that most noises listed on the survey were bothersome. Out of 14 room-related factors, this patient indicated that only one (heating/cooling/plumbing systems) did not affect her sleep. She reported that having to share a room with another patient "prohibits sleep", and also that nurses tended to be "at ease and talk too much especially at night". She indicated that this had reflected negatively on her sleep pattern. Another patient reported that because of numerous sleep disturbances at night, she was only able to sleep in short "cat naps". She blamed negligent staff, nurses being "at ease" and talking excessively, and states that because of the lack of sleep at night, the patient tends to 'loose the sense of day and night', therefore feeling disoriented.

A large number of patients commented on the non-noise related factors included in the survey, particularly lighting conditions both at the room level and in the corridor. One patient reported to be bothered by the lighting condition, specifying that "the nurse kept turning the light on at night". Another patient complained about the light levels in the corridor, stating that "leaving the door open at night allowed too much light into the room". There was also a positive comment related to the lighting levels, in which the patient indicated that having a "remote-controlled lighting switches was helpful".

The comfort of the bed, including the bed itself, pillows and sheets elicited a few comments. Two patients found the pillows to be "terrible, flat and uncomfortable". Another patient wrote that even though the pillows weren't comfortable, more were

provided per request. A few patients found the bed to be uncomfortable, and one found it to be too small.

Table 5 includes comments commonly made by individual respondents. These are meant to provide a general sense of satisfaction or frustration with various noise-related issues.

Table 5. Respondents' Comments

1	Keeping the door closed helped me sleep without many interruptions
2	Having to leave the door open at night allowed too much light into the room to be able to sleep
3	Having to get up to turn the light off after the nurse leaves the room is very inconvenient
4	Remote light switches were very helpful
5	More comfortable pillows could have improved sleep experience
6	Having a mobile weight station is a wonderful idea
7	I slept fine with the exception of being awakened for tests and procedures
8	Talking in the corridor was overwhelming
9	Nurses are at ease, talk too much, especially at night; they consider the unit 'their home', which is inconsiderate to pati
10	Used to the intercom paging - through dialysis, although bothersome
11	I never really slept, rather had random 'cat naps' throughout the day
12	Lack of sleep results in the patient feeling disoriented, loosing a sense of daily rhythms
13	Nurse left the door open repeatedly, which required the patient to get up to close the door
14	Primary reason for keeping awake is pain; noise and other environmental issues are secondary
15	Less interruptions would enhance sleep

Limitations

It is important to note that some aspects of the study might have influenced the results of this investigation. First, the use of convenience sample may have included only those who had relatively "good" stays and were reasonably well when they left the hospital. Second, including three units from the same building of the same hospital may have introduced a bias due to specific staff behaviors or exterior conditions. Third, while

collecting data prior to discharge proved to have a high response rate, collecting data on the morning of discharge may not have been the "best" time to collect this data as patients are anxious to be going home. Miscellaneous paperwork such as the survey used in the study may have been perceived as inconvenient and been dismissed or filled out without much concentration on the content

Despite these possible limitations, this investigation was successful at establishing a range of factors responsible for insufficient patient sleep, focusing on those related to noise. Sampling from three different units over a six-week period of time provided a good cross section of activities and conditions. Finally, to minimize inattention to the survey, the researcher made it a point to engage the respondent in completing the survey before leaving it to be completed, or administered it verbally, if the respondent preferred this method of administration.

Enhancement of Person-Environment Compatibility

The conceptual framework for this investigation was derived from Topf's (2000) model relating environmental conditions as factors (stressors) potentially impacting a person's health. In the present study noise was considered an environmental stressor that could negatively affect human health. The results of this study provided evidence that noise in a hospital environment is identified as a source of discomfort (resulting in sleep disruption) among a patient population. This supports the notion that noise as an ambient

stressor may negatively the health of an individual, thus requiring an intervention to either remove or lessen the noise from the hospital room environment.

CHAPTER VI

DESIGN RECOMMENDATIONS

Summary of Investigation

The survey in this investigation was designed for the purpose of identifying specific physical features and behaviors occurring on hospital units that patients identified as being disruptive to their sleep. Responses revealed that sleep-disturbing noise factors occur in the room, at the patient's bedside, as well as in the corridor. A total of 11 noise-related items were identified as potentially sleep disruptive by at least one-third of the respondents to the survey. The sources that were most disruptive were beeping of the IV pump, ringing of the telephone, intercom paging, equipment, staff activity and foot traffic in the corridor. Environmental factors not related to noise also were reported to be disruptive to sleep. These included temperature of the room, pillows, comfort of the bed, medical procedures and lighting.

Responses were analyzed to identify possible trends, which revealed very few (7) differences in responses when categorized by characteristics such as age, gender, hearing capability, length of stay and the involvement of surgical procedures. This finding supports the idea that most patients react to physical environments in very similar ways, and is therefore key to designing universal patient rooms.

Existing Physical Conditions

The units included in this study were all located on the same floor of the original Moses H. Cone Memorial Hospital building. As a result, physical conditions were consistent between the units. The exterior of the six-story building is faced with brick. All units studied were located on the fifth floor.

Corridor finishes consist of vinyl composition tile floor, most likely installed directly over the concrete slab. Gypsum board walls were covered with vinyl wallcovering, as well as occasional acrylic cornerguards and protective panels where needed. Acoustical ceiling tile throughout provide a certain level of sound attenuation. Elevator doors are stainless steel; other interior doors are painted metal. Metal patient charts are wall-mounted between every two patient rooms. General illumination is provided in the form of 2x4 fluorescent lay-in fixtures.

Corridor finishes are consistent with those in patient rooms. Patient room acoustical properties are enhanced by the presence of privacy curtains and fabric window valences. Each room has a laminate storage cabinet and a vinyl-upholstered recliner or lounge chair. Existing conditions typical of the fifth floor units are presented in exhibits 1 and 2.

Figure 7. Existing 5th floor corridor, typical.


Figure 8. Existing 5th floor patient room, typical.

Design Implications

Because the sources of hospital unit noise are numerous and complex, a multifaceted approach is essential for a successful solution. This approach needs to include behavioral and operational adjustments, equipment modification and design/construction detail changes. Some solutions need only involve adjustment of medical staff practices, however, to achieve a more comprehensive set of recommendations, this discussion focuses on identifying solutions achievable by informed design practices. While design recommendations are informed by the review of previously done research, solutions are proposed based on the findings of the current investigation. They are organized by the location of noise source, similarly to the arrangement of the survey, with measures proposed for (1) reducing or preventing the noise disturbance at its source and (2) providing solutions which lessen the opportunity for the sound to travel or enter the patient environment.

Bedside

Two sleep-disruptive noise factors located at the patient's bedside were identified by the survey responses: beeping of the IV pump/monitor and the telephone ringer. Both of these sources of noise disturbance may be prevented by addressing them at their source.

SOURCE OF DISCOMFORT: 74% of the respondents reported that beeping of the IV pump was disruptive to their sleep, making it the most frequent noise-related sleep disturbance complaint.

RECOMMENDATIONS: Existing IV pump warning indicators should be set to the quietest setting and future models should operate with light indicators. Finally, IV pump warning indicators may be routed to the nurses' wireless pager to eliminate signal sounds at the bedside.

SOURCE OF DISCOMFORT: The disturbance caused by telephone ringing can also be prevented or reduced at its source.

RECOMMENDATIONS: The ringer can be set on the lowest setting or turned off, providing voice mail availability, or replaced with models which operate with visual light indicators. This would allow a patient to sleep without being disturbed by the ringing of a phone, while providing a non-disturbing indicator when they are awake.

Patient Environment

A range of noise sources generated within the room were reportedly disruptive to patient sleep. Intercom paging was the second most common complaint among the respondents (60%), followed by noises generated by the nurse coming into the patient room (59%), medical cart being rolled into the room and nurse/doctor conversations both ranked by 38% of the respondents. Recommendations addressing these concerns consist

of a blend of operational/behavioral changes, design implications and equipment modification. A certain portion of these noises can be lessened at the source.

SOURCE OF DISCOMFORT: The issue of intercom paging within the room can be resolved by the adjustment of equipment and operational procedures.

RECOMMENDATIONS: The introduction of personal wireless pagers for all staff may be the first step toward the alleviation of this problem. Paging of staff over the intercom could be substituted by using personal pagers that vibrate. A nurse call system could be set up to go directly to the nurse's pager, rather than the nurse station. Leaving the intercom system in place, but using it only in emergencies and for announcements to the general public could also eliminate unnecessary noise disturbances within the patient environment.

SOURCE OF DISCOMFORT: Noises associated with a nurse coming into the room are more complex and might involve a number of approaches.

RECOMMENDATIONS: In order to reduce the number of times a nurse enters the room and therefore lessening the frequency of this noise source, visual access to the patient could be provided between the corridor and the patient bed. A built-in charting station at each room entrance will provide the nurses and doctors a permanent area for filling out paperwork while being able to see the patient. A simpler solution may consist of a visual panel within the door/portal. To make the visual access possible and allow flexibility and privacy, a view-blocking system (blinds, shades) should be provided,

operable from both the inside and outside of the room. Giving nurses the ability to see the patient from the corridor will reduce the number of times the nurse will open the door or walk inside, potentially disturbing the patient sleep. Installing surveillance cameras in patient rooms to be monitored from the nurses' station may be viewed as intrusive, but also could satisfy the need visually check in on patients without physically disturbing them. Non-critical patients may have an option to have the camera surveillance or not, while more critical patients would have the camera on at all times.

Further potential of lessening the amount of noise and sleep disruptive behaviors generated by the nurses' entering the room requires an adjustment in staff behavior/operations. Educating the staff on the importance of sleep and ways to adjust their behavior to enhance the sleep-promoting environment may prove to be an effective way of reducing the amount of unnecessary noise disturbances. Because a majority of the patients found it most difficult to sleep during the night, implementing guidelines to protect patient sleep during the night by adjusting existing procedures may be helpful in reducing noise when it is found to be most disturbing to their sleep. Nursing staff should be trained to provide medical service with the focus on the patient needs, rather then commonly-accepted procedures due to ease of operation or habit.

Providing a low level of task lighting in the nurse's work area within the room could allow a certain ease of getting around and accomplishing necessary tasks without much difficulty and noise disruption. With sufficient low lighting levels medical staff should be able to provide for the needs of patients with minimal disruption. Since lighting was found

to be sleep-disruptive, however, attention should be given to how this level of light will affect the patient's ability to sleep.

SOURCE OF DISCOMFORT: Medical cart being rolled into the room was another common complaint among the survey respondents.

RECOMMENDATION: To stop or lessen the noise at its source, medical carts should be equipped with soft rubber wheels. Other parts of the cart could also be designed to avoid unnecessary noise, such as ensuring metal parts don't come into direct contact and using soft drawer liners to soften the sound of metal items being dropped into the drawer.

SOURCE OF DISCOMFORT: Nurse/doctor conversations within the room were found disturbing to patient sleep.

RECOMMENDATIONS: Instructing the medical staff to keep their voices down during conversations, avoiding unnecessary communication within the patient environment, and consulting outside of the patient environment This could be supported by providing consultation areas throughout the corridor, away from patient room doorways, but remaining in close proximity to the patient rooms.

GENERAL RECOMMENDATIONS: While addressing individual sources of noise within the room can prevent some noises from being generated and lessen the amount of other types of noises, a certain degree of sound will still be generated by these activities. Therefore, when feasible patients' room should be constructed or redesigned to enhance

sleep by absorbing sounds generated. All surfaces of the patient rooms should be built to minimize noise intensity, reflection and transmission. This might include installation of flooring material that can increase sound absorption and reduce the reflection and transmission of sound when it cannot be eliminated at the source. For example, the use of acoustical flooring such as Forbo Marmoleum Acoustic flooring, which is composed of a 2 millimeter underlayer and a 2 millimeter layer or linoleum and is designed to achieve a 14 d(B) impact sound reduction (forbo-flooring.com) and may be a possible solution. Acoustical ceiling tile with maximum sound absorption qualities also could be installed in the patient environment. Fabric window treatments may provide additional sound-lessening qualities. Other installation methodologies which can enhance sound attenuation between the room and the corridor will be addressed as a part of general corridor recommendations.

Another major suggestion for noise-reducing efforts within the patient environment is incorporation of all-private patient rooms. A typical patient room is designed to accommodate the nurse/doctor, the patient, and family members. Semi-private rooms provide space for patient care for two or more occupants, which also increases both the noise sources and the level of noise that patients might experience.

The 2006 version of the AIA Guidelines for Design and Construction of Healthcare Facilities dictates that all surgical, medical and post-partum patient rooms are to be single-bed, or private (Chapter 2.1, General Hospitals, is 2.1-3.1.1). Each patient's care involves a number or factors which might be disturbing to another occupant of a patient's

room. Single rooms would eliminate noise sources that come from other patients in the same room and would decrease disruptions from medical personnel entering the room, having conversations or other activities inside or directly outside of the room, noise factors generated by visitors, equipment, and patient-generated noise such as the use of the telephone, toilet and shower. Dedicating a protected environment for each patient would likely decrease the incidence of noise-caused discomforts and increase control and overall satisfaction. An added benefit of providing all private patient rooms is its suggested effectiveness in reducing the possibility of nosocomial infections, according to a study conducted across four West-coast hospitals by Chaudhury, Mahmood and Valente (2003).

Corridor

A major source of sleep disruptive noise identified by respondents came into the room from the corridor. The most disturbing factors identified were: nurse/doctor conversations (55%), staff activity (43%), rolling carts and equipment (38%), people walking (37%), and intercom paging system (35%). Many of these noises may be prevented or lessened by addressing them at their source.

SOURCE OF DISCOMFORT: Nurse/doctor conversations in the corridor were disruptive to more than half of the survey respondents.

RECOMMENDATIONS: Raising the staff awareness of this problem and informing them of possible solutions may minimize the amount of this noise disturbance. Nurses and

doctors could be instructed to keep their voices down during conversations and to avoid unnecessary communication directly outside of patients' rooms. Providing consultation areas in close proximity, while away from the patient room could direct conversations to designated areas, alleviating random corridor conversations.

Decentralizing the nurses' station may be another method of reducing the amount of conversations. Removing large gathering spaces, such as a central nurse's station, from the patient environment should be effective in reducing the number of conversations taking place. Placing the nurses with the patients in a de-centralized nurse's station configuration should increase direct nurse supervision and reduce the number of times nurses spend in a central shared area, therefore reducing non-essential social conversations. Centralized areas of staff congregation could be located away from the patients' rooms and designed to contain generated sounds.

Providing visual access into the patient room from the corridor by the means of a vision panel within the door itself or adjacent to the room entrance would enable the door to remain closed, while allowing visual surveillance of the patient, therefore reducing the transmission of sound from the corridor into the room. This may contribute to the patient sleep by eliminating potential disturbances due to staff conversations in the corridor.

SOURCE OF DISCOMFORT: A large percentage of survey respondents indicated finding staff activity in the corridor to be bothersome to their sleep. Certain design and operational modifications might decrease the severity of this noise-generating factor.

RECOMMENDATIONS: The reduction of noise may be achieved by eliminating noise-generating materials and equipment such as operable metal patient charting stations and replacing them with built-in countertops adjacent to each patient room entrance. Introducing paperless operation could eliminate the amount of paperwork kept near (or within) the patient room, which is usually organized in binders. The use of this material can contribute to considerable noise when there is a high amount of paper handling, and opening and closing of charts. Providing a built-in charting station with a wall-mounted monitor and keyboard would reduce miscellaneous items (including charts) from being shuffled around or dropped.

Further potential noise reduction could be accomplished by installing acoustical panels in areas of increased staff activity to increase the absorption of noise that tens to be transferred to adjacent areas. Other material installations that could reduce the transmission of noise from where it is originally generated are addressed in general recommendations.

SOURCE OF DISCOMFORT: Disturbance caused by the rolling carts and noisy equipment in the corridor could be prevented by a combination of modifications.

RECOMMENDATIONS: Using rolling equipment with soft rubber wheels is one simple modification. Providing localized equipment storage areas could reduce the quantity of transfers of the equipment within or between units, further reducing the potential of noise generated by transporting equipment.

Noise which cannot be prevented completely can be softened by specifying flooring material with sound considerations. A cushioned resilient product (such as the Forbo product) may be used in corridors. If carpet is considered for the corridor flooring for its sound-reducing qualities, installing a tiled product will simplifying the maintenance procedures.

SOURCE OF DISCOMFORT: The sound generated by people walking in the corridor might be addressed by two approaches.

RECOMMENDATIONS: First, de-centralized nurses' stations and localizing equipment and supply storage areas could reduce the distances traveled by the staff. Reducing the amount of time staff spend walking between the nurses station, individual patient rooms, storage and auxiliary areas reduces foot traffic in turn would eliminate unnecessary traffic and subsequent noise. It will also contribute time saved from walking to patient-related needs, increasing staff efficiency.

Sound absorbing materials are an essential part of the solution to noise generated by walking. Cushioned resilient products, even a separate cushion layer or carpeted floors hold the potential in reducing noise generated by the impact of shoe on the flooring material.

SOURCE OF DISCOMFORT: Similar to the patients' concern of intercom paging within the room, the same complaint was identified in the corridor.

RECOMMENDATIONS: The overhead paging system could remain in place for the purposes of addressing the public in cases of emergency announcements. All other staff communication could be directed to personal vibrating wireless pagers. This operational adjustment would eliminate a large portion of announcements, therefore ensuring a quieter environment.

GENERAL RECOMMENDATIONS: Because all sound (conversations, staff activity, foot traffic and rolling equipment) cannot be stopped at the source, similar to the recommendations for the patients' rooms, measures need to be taken to increase sound absorption and reduce the sound transmission path to prevent it from entering the patient environment. The door is intended to prevent noise from entering the room, and it should be insulated and equipped with a door sweep to further reduce the sound transmission path under the door. Because there is usually a gap between the finished floor and the bottom of the door, a door sweep can help in covering the gap, therefore preventing the sound from entering the room through the opening.

By focusing on the noise-related factors, aside from the very particular solutions to the specific problems, general unit-wide adjustments could reduce the amount of noise generated and passing through the environment. Most surfaces found in a hospital corridor are hard and reflective, primarily for the ease of maintenance and cleanliness. Replacing resilient flooring in the corridor with carpeting could introduce a soft, sound-attenuating surface. Carpet tile, instead of a broadloom product, would reduce the maintenance of the flooring, allowing individual pieces to be replaced as needed.

Acoustical ceiling tile with maximum sound attenuation qualities and acoustical panels installed in areas of increased activity could both be used to lessen the amount of sound leaving those areas.

Construction details could be adjusted to include the use of resilient cold-rolled metal studs instead of structural studs and adding a layer of sound attenuation board on each side of the wall prior to the layer of gypsum board to help mediate noise transmission through the wall into the patient room. Acoustical insulation between the studs should be included to provide for maximum sound absorption.

The layout of the unit and the room can play a major role in preventing the noise from entering the patient room from the corridor. For instance, installing storage cabinets on the wall separating the corridor from the patient room could provide a sound buffer, reducing the noise generated in the corridor from entering the patient space. Another possibility is placing the bathroom on the corridor wall, rather than the exterior wall, which could also potentially reduce sleep disruptive sounds coming through the wall. While there are certain activities which would be generated in the bathroom such as running water and the flushing of the toilet, in case of private rooms, these factors do not carry much significance, since the patient would be the primary user of the space.

The sources of hospital unit noise are numerous and complex. The efforts to reduce noise levels should embrace a variety of approaches, from behavioral/operational, to design-related modifications and equipment specifications. Noises which cannot be prevented by these modifications can be lessened and stopped from entering the patient

environment through a well-informed use of construction methods and careful selection of interior finishes.

Non-Noise Sleep Disruptive Factors

SOURCE OF DISCOMFORT: The most frequent non-noise sleep disruptive complaint was related to the comfort of bed.

RECOMMENDATION: The patient bed model should be investigated and perhaps even brought in for trial prior to installation in any unit. While further investigation is needed to understand the particular complaints about the discomfort of the bed, the solution may be as simple as a better, more comfortable mattress.

SOURCE OF DISCOMFORT: Nurse and medical intervention was a source of many respondents' complaints.

RECOMMENDATIONS: The solution lies in operational changes to the method of administering care. Nursing and medical staff need to be trained on the importance of patient sleep and instructed to deliver patient-centered care, rather than procedures accepted due to the acquired habits or ease on the nurses' part. For example, non-critical patients may not need to be awakened for minor routine check-ups.

SOURCE OF DISCOMFORT: Room temperature was commonly described as a sleep-prohibitive factor.

RECOMMENDATIONS: An immediate solution may be providing additional blankets for the patient. Placing temperature and lighting controls near the patient bed may be a more permanent solution and can minimize stress and enhance the person-environment compatibility.

SOURCE OF DISCOMFORT: Pillows were found to be a source of discomfort by a large portion of survey respondents.

RECOMMENDATIONS: The findings reveal that simple items like bed pillows make the difference between a restful and a sleepless night. Specifying pillows to be of a higher grade, fuller and softer than those which are commonly found in hospitals is a simple solution; stocking pillows in various sizes to cater to various patient preferences could potentially address patient concerns and provide personalized, home-like comfort for each individual.

SOURCE OF DISCOMFORT: Medical procedures were commonly noted on the survey as a sleep-disruptive factor.

RECOMMENDATIONS: Similar to the staff intervention, non-critical medical procedures should be scheduled with patient's sleep and comfort in mind. To achieve this, medical staff should receive training on ways to minimize having to awaken the patient for a range of non-critical medical procedures.

SOURCE OF DISCOMFORT: Finally, respondents noted that lighting levels within the patient room were not appropriate for sleep.

RECOMMENDATIONS: Similar to the suggestions relating to temperature controls, lighting controls could be provided to the patient at bedside. Providing mechanized window treatments, even operable windows, could introduce an additional level of flexibility, therefore, ensuring that patients are able to adjust their environment for their individual comfort.

Table 6 presents a summary of solutions proposed to address areas of concern as identified by the participants of the survey. Incorporating design recommendations with behavioral and operational changes should increase the person-environment compatibility within healthcare facilities in terms of noise.

Table 6. Design Recommendations

LOCATION	SOURCE OF DISCOMFORT	DESIGN RECOMMENDATION
Bedside	Beeping of IV pump / monitor	Replace beeping with light indicator Set warning indicator to quietest setting Direct the warning indicator to nurse's wireless personal pager
	Phone ringing	Give patient the option of turning the ringer off Install telephones with light indicators, rather than ringers
Room	Intercom paging system	Use only for emergency announcements for the general public Introduce personal wireless pagers for all staff communication
	Nurse coming into the room	Allow visual access from the corridor (at charting station, door, etc.) Propose camera surveillance Provide low level of lighting, enough to get around at night Train nursing personnel to be considerate of patient sleep
	Med cart rolled into the room	Install flooring material with sound attenuation properties Specify med. carts with all parts designed for silent operation Specify med. carts with soft rubber wheels
	Nurse/doctor conversations	Provide designated areas for the medical consultation Train nursing personnel to speak softly, avoid unnecessary communica
Corridor	Nurse/doctor conversations	Train nursing personnel to be considerate of patient sleep *Provide additional wall insulation (sound attenuation board)* Provide designated areas for consultation away from patient room Decentralize nurses station Enable visual access into patient room to keep the door closed
	Staff activity (charting, binders, etc.)	Introduce paperless operation Incorporate built-in computerized charting stations Increase sound attenuation between corridor and room *Specify sound-absorbing corridor finishes*
	Rolling carts, equipment	Investigate flooring material choice - carpet, cushioned resilient flooring Specify rubber wheels/casters on equipment Design localized equipment storage areas to reduce transport distance *Install sound-absorbing corridor finishes* *Increase sound attenuation between corridor and room*
	People walking	Investigate flooring material choice - carpet, cushioned resilient flooring Reduce the travel distances for staff - nurse station, storage rooms *Install sound-absorbing corridor finishes* *Increase sound attenuation between corridor and room*
	Intercom paging system	Use only for emergency announcements for the general public Introduce personal wireless pagers for all staff communication
Non-Noise	Comfort of your bed	Specify more comfortable bed model Install more comfortable mattress
	Nursing and medical intervention	Time all procedures with the patient in mind (patient-minded care)
	Room temperature	Introduce patient-operated room controls, at bedside
	Pillows	Stock pillows in various sizes Make additional pillows available to the patient Specify more comfortable pillows
	Medical procedures	Time all procedures with the patient in mind (patient-minded care)
	Lighting in your room	Introduce patient-operated room controls, at bedside

CHAPTER VII

CONCLUSION

This investigation was designed to identify what factors within the patient unit were found to be disruptive to sleep by the patients, and consequently to recommend design changes addressing areas of concern. Patient survey responses presented a range of individual factors perceived to be problematic, both noise and non-noise related. Respondents' characteristics revealed only minor effects on the perception of noises, signifying that overall, noises are perceived similarly across age ranges, gender and procedural differences, the length of stay and largely even hearing impairment.

A total of 11 noise-related items were identified as potentially sleep-disruptive by at least one-third of the respondents. Items receiving the highest amounts of responses were: the beeping of the IV pump/monitor (74%), intercom paging within the room (60%), nurse coming into the room (59%) and nurse/doctor conversations (55%). Other common complaints included staff activity and conversations, foot traffic and equipment-related noises. Six additional items were recognized as destructive to sleep, including comfort of the bed and nursing and medical intervention, room temperature and lighting levels, pillows and medical procedures.

Patients concerns were documented using the patient survey. Because the sources of noise and sleep disruption were complex, a holistic approach is essential for a successful resolution. The results were analyzed and translated into a set of practical

design recommendations as well as certain suggestions for operational modifications. Recommendations were developed for three areas of noise-generating activities – at the patient bedside, within the room and in the corridor. Suggestions were provided which would help prevent or reduce the generation of noises at the source. These included design and operational implications. Because not all noises can be eliminated from the patient environment, general recommendations for room attenuation, including construction details and materials were provided.

Introducing a more holistic approach to the reduction of noise-related sleep-disruptive factors can yield physical environments more sensitive to patient sleep, enhancing the person-environment compatibility and ensuring that patient's needs and goals are met without obstacles. Based on this study, sleep deprivation caused by excessive noise is as a major patient-related concern.

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APPENDIX A

SURVEY

ASSESSING SLEEP-DISRUPTIVE NOISE FACTORS IN HOSPITAL PATIENT ROOMS
University of North Carolina at Greensboro

INFORMED CONSENT FORM

Dear Sir or Madam:

You are invited to participate in a survey designed by an Interior Architecture graduate student at UNCG. In an effort to understand sleep-disruptive noises in patient rooms, we are asking you to tell us about the noise levels you've experienced during your stay at Moses Cone.

The survey is anonymous. It will take 5-10 minutes of your time and your participation is voluntary. If at any point you feel uncomfortable answering any questions, you can withdraw from the survey.

Benefits: Your participation will help identify potential sources of noise that are disturbing to patient sleep. Design solutions will be developed in an effort to reduce these sources of noise.

Risks and discomforts: There are no foreseeable risks associated with your participation.

Data Confidentiality: your survey responses will be strictly confidential and information from this research will be reported only in connection with this study. The data will be kept in a locked secure location for up to two years, after which it will be destroyed by the process of shredding.

Institutional Review Board: This research has been approved by the Institutional Review Boards at the Moses Cone Health System and the University of North Carolina at Greensboro. Please direct any questions regarding your rights as a participant in this project by contacting Eric Allen at UNCG (336.256.1482) or Debbie Green at Moses Cone (336.832.7442).

By signing this form, you are agreeing to participate in the study described above.

Signature: _____ Date: _____

Thank you for agreeing to take part in this research effort. We know that your time is valuable and we greatly appreciate your assistance. Please start the survey on the next page.

Nadia V. Volchansky . 814.566.1755 . nvvolcha@uncg.edu

ASSESSING SLEEP-DISRUPTIVE NOISE FACTORS IN HOSPITAL PATIENT ROOMS

University of North Carolina at Greensboro

PLEASE CHECK WHETHER OR HOW MUCH EACH ACTIVITY LISTED BELOW INFLUENCED YOUR *SLEEP* DURING THE STAY *IN THIS ROOM*.

		A LOT	A LITTLE	NOT AT ALL
bedside	phone ringing			
	beeping of IV pump / monitor			
	suction/oxygen/air hose noise			
	other noise (specify)			
room	intercom paging system			
	TV / radio			
	med cart rolled into the room			
	cleaning crew			
	nurse/doctor conversations			
	nurse coming into the room			
	visitors conversations			
	opening / closing of the door			
	heating / cooling / plumbing systems			
	running water at the sink (hand washing, etc.)			
	flushing the toilet			
	exterior noise (coming through the window)			
	other patient noise			
	other noise (specify)			
corridor	people walking			
	nurse/doctor conversations			
	telephone ringing			
	items being dropped			
	rolling carts, equipment			
	intercom paging system			
	staff activity (charting station/binders, etc.)			
	noises you cannot identify			
	other patient noise			
	other noise (specify)			
other	list any other **noises** which disturbed your sleep			

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ASSESSING SLEEP-DISRUPTIVE NOISE FACTORS IN HOSPITAL PATIENT ROOMS

University of North Carolina at Greensboro

PLEASE SPECIFY ANY OTHER FACTORS WHICH AFFECTED YOUR *SLEEP*:			
	A LOT	A LITTLE	NOT AT ALL
lighting in your room			
lighting in corridors			
comfort of your bed			
pillows			
odors			
room temperature			
nursing and medical intervention			
medical procedures			

DURING WHICH PART OF THE DAY WAS **NOISE** MOST DISRUPTIVE TO YOUR **SLEEP**? (circle all that apply)

early morning late morning afternoon early evening night

Please provide any comments regarding your sleep experience or the levels of noise during your stay in this room: .....

.....

.....

.....

What do you feel could enhance your sleep during hospital stay? .....

.....

.....

.....

Today's Date: _____ Room #: _____

Gender: _____ No. of nights spent in this room: _____

Age: _____

Was surgery involved in your stay: yes no

Do you have a hearing impairment? yes no

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APPENDIX B

RAW DATA

Table A. All Survey Responses

			Extent Respondents' Sleep Was Disturbed					
			A Lot		Some		None	
Location	Noise Source	Total N	N	Percent	N	Percent	N	Percent
Bedside	beeping of IV pump / monitor	61	24	39	21	34	16	26
	phone ringing	59	7	12	15	25	37	63
	other noise (specify)	34	4	12	7	21	23	68
	suction/oxygen/air hose noise	54	2	4	7	13	45	83
Room	intercom paging system	60	9	15	27	45	24	40
	nurse coming into the room	61	16	26	20	33	25	41
	med cart rolled into the room	60	3	5	20	33	37	62
	nurse/doctor conversations	60	8	13	15	25	37	62
	cleaning crew	60	4	7	15	25	41	68
	opening / closing of the door	59	10	17	8	14	41	69
	visitors conversations	59	2	3	15	25	42	71
	heating / cooling / plumbing systems	57	6	11	10	18	41	72
	other noise (specify)	33	5	15	3	9	25	76
	TV / radio	61	5	8	9	15	47	77
	exterior noise (coming through the window)	58	4	7	9	16	45	78
	other patient noise	51	6	12	5	10	40	78
	flushing the toilet	56	2	4	6	11	48	86
	etc.)	56	1	2	4	7	51	91
Corridor	nurse/doctor conversations	53	13	25	16	30	24	45
	staff activity (charting station/binders, etc.)	51	7	14	15	29	29	57
	rolling carts, equipment	53	5	9	15	28	33	62
	people walking	54	6	11	14	26	34	63
	intercom paging system	52	5	10	13	25	34	65
	items being dropped	53	4	8	11	21	38	72
	telephone ringing	52	2	4	10	19	40	77
	other patient noise	48	5	10	6	13	37	77
	noises you cannot identify	50	3	6	8	16	39	78
	other noise (specify)	27	2	7	1	4	24	89

		Extent Respondents' Sleep Was Disturbed						
			A Lot		Some		None	
	Other Environmental Factors	Total N	N	Percent	N	Percent	N	Percent
Non-Noise	comfort of your bed	60	14	23	20	33	26	43
	nursing and medical interventio	58	10	17	19	33	29	50
	room temperature	59	7	12	19	32	33	56
	pillows	60	9	15	17	28	34	57
	medical procedures	55	7	13	16	29	32	58
	lighting in your room	60	7	12	14	23	39	65